Biolife 6(3):1-14
AN INTERNATIONAL QUARTERLY JOURNAL OF BIOLOGY & LIFE SCIENCES
ISSN (online): 2320-4257
www.biolifejournals.com
BIOLIFE ORIGINALARTICLE

Anthropogenic Actions on Population Density of the Barbary Macaques in Eastern Middle Atlas, Morocco

Faical Boutlib[1]*, Camille M.F. Deman[2], Jad Tahouri[3], Raja Guemmouh[4]

[1,4] Laboratory of Biotechnology and Preservation of Naturals Resources,Department of life sciences, Faculty of Sciences Dhar el Mahraz, University Sidi Mohamed Ben Abdellah, Fez- Morocco.
[2]Moroccan Association for Protection of Heritage and Barbary Macaques, Fez, Morocco.
[3]Laboratory of Geodynamic and Naturals Resources, Department of Geology, Faculty of Sciences Dhar el Mahraz, University Sidi Mohamed Ben Abdellah, Fez- Morocco

*Email:*faysalbo@gmail.com

ABSTRACT

The Barbary Macaque (Macaca sylvanus) lives in the forest biotopes of Algeria and Morocco. It is found mostly in the cedar forests of the Middle Atlas Mountains, where it lives in structured groups. In the Eastern Middle Atlas, in addition to cedar forests, it also lives on rocky outcrops. In these places, the groups are not isolated by habitat degradation and caves are used as dormitories. In the Eastern Middle Atlas, we counted the existing monkeys by a simple scan. The study showed that the remaining populations of monkeys have a large turnover of individuals. We summarize that the high proportion of young individuals and good preservation in the Eastern Middle Atlas. that there is neither strong anthropization of the groups nor poaching of the young macaques.

Key words: Anthropization, Barbary macaque, Conservation in situ, demography, Morocco, Eastern Middle Atlas.

INTRODUCTION

The Barbary macaque (*Macaca sylvanus*, (Linnaeus 1758) is the only non-human primate in northern Africa. This species is placed into silenus-sylvanus group, one of the four phylogenetic groups (Abegg and Thierry, 2002).This palaeoendemic species was historically distributed throughout the Mediterranean region, but since the Pleistocene (Simons 1972; Camperio Ciani 1986), its population and distribution have shrunk to relict locations in Morocco and Algeria (Fa 1984). Furthermore, studies have shown that this and other macaques have experienced successive bottlenecks during the Pleistocene glaciations (Scheffrahn et al. 1993; Modolo Lara.et al. 2005). Consequently, Barbary macaque is currently listed as endangered in the IUCN red list of threatened species (IUCN 2011).

How to Cite this Article:
Faical Boutlib, Camille M.F. Deman, Jad Tahouri, Raja Guemmouh(2018).Anthropogenic Actions on Population Density of the Barbary Macaques in Eastern Middle Atlas, Morocco. *Biolife*. 6(2), 1-14.
DOI: 10.5281/zenodo.7403053

Received: 12May2018; Accepted: 25June 2018; Published online: 18 July, 2018

Barbary macaque can be found in both low and high elevation areas (Cuzin 2003), occupying a wide range of habitat types including forests, desert dunes, rocky cliffs and summits of high mountains. However, the population density of this species varies widely with habitat type (Fa J.E, Taub D.M., Ménard N., Stewart 1984; Ménard N.1985b; Camperio Ciani 1986; Ménard N.&Vallet 1993a; Scheffrahn et al. 1993). Furthermore, but natural history and literature have shown significant population fluctuation (Taub D.M.1975; 1977; Hodges, 2006; Van Lavieren 2008).

In Morocco, Barbary macaques are found mainly in high-altitude cedar forests in the Middle Atlas, where the population is estimated to be between 10,000-15,000 animals (Mehlman 1989). In the Middle Atlas, which contains 70% of the total population of Morocco (Camperio Ciani 1986), this number has dropped by about 65% over the last three decades (Taub 1977) to 5000 (Van Lavieren & Wich 2009; Ménard et al. 2009). Furthermore, Barbary macaques are distributed in the cedar forests of Sidi M'Guild, Ifrane, and Michlifen, green oak groves of Ain Leuh, El Hammam, between Azrou and Ain Leuh and Aliouane south forests. The population of this species is also found in the mixed forests of cedar and oak in Tamgilt and Taffert in the Middle Eastern Atlas (Boutlib F., Guemmouh R. et Deman C.M.F. 2016). The Barbary macaque can be used as a flagship species for

the endangered fauna and flora of Moroccan ecosystems.

Various authors (e.g. Deag 1974; Taub 1975; Drucker 1984) have noted Barbary macaque's capacities to colonize various habitats due to its great adaptability to a wide range of habitats. On the contrary, these reports did not consider the amount of available resources in these habitats and the dispersal preference of the animal populations.Among anthropogenic actionsthe fragmentation of habitats by overgrazing is responsible for the decline of wild Barbary macaque populations in Morocco. This factor has favored also the isolation of the remaining subpopulations (Hayasaka, Fujii, Horai 1996). Indeed, overgrazing is exacerbated by the succession of years of drought and accentuated by the sedentarization of pastoralists (Mouna M., Arahou, Camperio Ciani 1999). Its increase leads to the loss of biodiversity impacting the ecology of feeding behavior of barbary macaques .The major impact, it should be clear, is caused by the continuous growth of flocks pastured by the Berbers. This growth however contrasts with the extremely poor living condition of this population. The presence of tourists and their frequent physical interactions with Barbary macaque could affect the normal behavior of these primates. This change in behavior manifests itself through the increase in assaults and the reduction of affiliation behaviors. Thus, tourism can increase the level of physiological stress of animals with negative consequences on their health and their reproduction. A study carried out by Maréchal L.et al (2011) has highlighted these impacts on male Barbary macaques in the Ifrane National Park, specifically the factors affecting these animals, namely levels of anxiety and stress. Anxiety levels in males increased with the number of tourists present and with the rate of macaque/human interactions, whether these interactions were neutral, food or aggressive (Maréchal L. et al.2011; Ménard N. & Vallet D.1997). In addition, the supply and feeding of Barbary macaques by tourists by the roadside are increasingly exposed to poaching and traffic accidents and tourism is also responsible for a growing deterioration of the forest environment (Boutlib F., Guemmouh R. et Deman C.M.F. 2016). The main threat to the species (Camperio Ciani et al. 2005), because the destruction of the forest cortege, caused mainly by overgrazing, degrading for crops, logging, increasingly reduces the area of the habitats of the Barbary macaques, thus fragmenting populations of the species in small isolates, thus weakening the whole of the Barbary macaque population (Camperio Ciani, Martinoli L., et al. 2001 ;Ménard and Vallet 1986, 1997; Ménard et al. 2009) in the Middle Atlas, where some forest management practices were considered inappropriate, such as cutting old cedars offering monkey refuges and reducing or eliminating green oak which was an important resource for macaques (Camperio Ciani et Casillo P. 1996).

Therefore, this study aims to investigate and document populations of Barbary macaques in the Eastern Middle Atlas Mountains and compare findings with those of Taub (1977) .The Barbary macaque population of this area was estimated to be between 100 and 200 individuals, reported to be endemic to pockets of cedar and green oak forests and maritime pines to the south of Djebel Tazekka (Taub 1977).For an accurate comparison, we chose the same study area used in Taub (1977, 1978) population studies of this species.

MATERIALS AND METHODS

Study site

The Eastern Middle Atlas, located between latitude 33° 30′ 0″ N and longitude 4° 30′ 0″ W, has the highest peaks of the entire Mesa-Atlantic chain (Rahou 1996). This area is noted for relatively high plant species richness, distributed along elevation and geographical gradients. The topography of the Middle Atlas is steep and rocky making it inaccessible.

The Eastern Middle Atlas is the northern part of the Middle Atlas (Error! Reference source not found.) includes the Tazekka National Park (but macaques were not found in this region). It also includes three sites of biological and ecological interest; Bou Iblane 1 and 2 and Taffert (the existence of the Barbary macaques), El Adrej, Bou Nacer, Jbel Tichoukt (Error! Reference source not found.).

The Tazekka massif is very humid and has one of Morocco's highest rainfall. Surrounded by the mountains of Djebel (Dj.) Moussa o Salah (alt. 3218 m), Dj. Bou Iblane (alt.3260m) and Dj. Bou Nacer of the Guelb er Rahal range (approx Alt. 3400m). Guelb er Rahal range dictates the local weather conditions due to rain shadow and the eastern region's predominant dry arid vegetation. On the humid western aspect, water rushes into the deep valleys creating small rivers and permeates the rock to emerge later as springs. It is a significant water source for the local Moroccan people.

Below Tamgilt in approximately 103 ha of mixed cedar and oak forest; A small area around Taffert at Tine H'lilt; and at Tahafourt approximately 100 ha of mixed cedar forest between 1400-1700m altitude about 5 km south of Herhraoua. In the zone of Tallet, The green oak is mixed with boxwood, red juniper, and Alfa. Maritime pine replaces green oak on marly limestone at approx. 2000m; Cedar is very sparse and low at higher altitudes. (It is well known in the extreme western zone with a subhumid and humid bioclimate, and at Dj Tazekka at low altitude mixed with cork oak and green oak), whereas at Tanemilt there is pure cedar forest; Chamephytes dominate the base altitude; *Alyssum spinosum*, *Bupleurum spinosum* and *Chamerops humilus* at times mixed with green oak and Aleppo pine and reforested areas (valley of OuedTaffert-Karya, and valleys of Oued Mdaoud); Alfa steppes (low altitude southern and Eastern regions, bioindicator of arid and semi-arid bioclimates); Tetraclinae (northern slope of the Jbel Aghezdis in a semi-arid bioclimate); Red Juniper (Oued Beni-Mansour, southern slope of Guelb er-Rahallaisse); Aleppo Pinewood *Pinus halepensis* (Beni Bou-Illoul, Tamgilt, Mukraz and on the southern slope of Guelb er-Rahal in a subhumid microclimate (Fennane

1982).Aleppo pine is sporadic in the region between Bou-Iazitene and Ich Tiffirassine. It covers marly limestone soil in areas associated with *Rosmarinus officinalis-Tetraclinetum* spp. (Fennane 1982); In the east of Tamgilt on the southern side, it is interspersed with red juniper and Green Oak. It is also located on the sides of the Rawyana valley; Marine pine *Pinus pinaster* is found mainly in cool and cold subhumid and humid temperate climates, generally on marly and other limestone (Bou Iblane, Bou Nacer); Buxaie (at the bottom of the valleys of Beni-Mansour), Subaery of Bab-Azhar;Thuriferaie (It forms a discontinuous band above the cedar and oak groves in a subhumid bioclimate and the high mountain stage); Xerophytes spinous covers the alpine summits of Dj. Bou Iblane, Dj Moussa o Salah, and the peaks of the Guelb er Raha range,. where we noticed that macaque groups tolerated a sole human to a distance of about 40m when on steep slopes. In this region, the ecosystem appears to be degenerating, with thin, discontinuous cedar and green oak forests of poor quality (Taub 1977; Waters et al. 2015).

Data Collection

Data collection was carried out between 10th January 2014 and 28th June 2015 within the study areas. Study areas were mapped using a 50 m quadrant grid system based on visibility in the habitat (Ménard et Vallet 1993a). For counting a population of Barbary macaque in the study area, we used stratified sampling by transect method with a line transect (Altmann 1974) and width repeated-transect method (Caughley 1977; National Research Council 1981; Pinto et al. 1993).When we found a group, we stopped and started counting the individuals, I distinguished six age-sex categories(**Error! Reference source not found.**). Adult males are always the last to flee, so we paid special attention to males during group observations (Waters et al. 2015). These males were identified by individually distinct physical characteristics (scars or their box) observed with binoculars at a distance of about 30-40 m.

Table 1. Age-sex class of Barbary macaques used to determine group composition

age-sex class	definition
Adult male>5 years	full body size; fully developed testicles
Adult female >5 years	full body size; differentiated from males at a distance by the appearance of genitals and/ or presence of elongated nipples
Unknown adults >5 years	Adults of unidentified sex; full body size
sub-adults>3-5 years old and juveniles >1-3 years old	Blonde in color; slender body; smaller than full body size
Infant(6 month - 1 years)	small size; between 20-50 cm
Babies (between 0-6 month)	les nouveau-nés ont des poils noirs (-20cm)

The groups of Barbary macaques were studied in five following sites: 1) Mdaoud (33°44’37 "N; -4, 11 ' 54 ° W). Rocky lawns dominate the stratum of Chamephytes under green oak and Aleppo pine (endemic) and maritime pines (reforested). 2) Karya (33 ° 41'4.15 "N; - 4 ° 13'11.88" W), a forest of green oak and red juniper (east of Tamgilt) (*Juniperus oxycedrus*). 3) Tamgilt (33 ° 35'40.15 "N; 4 ° 1'28.21" W) brushwood of juniper and Aleppo pine (*Pinus halepensis*). 4) (Beni Bou-Illoul) in Tanemilt (33 ° 46'32 "N; 4 ° 12'57" W) Cedar forest (*Cedrus atlantica*). 5) Taffert (33 °39'55 "N;-4°11'40"W) Cedar forest (*Cedrus atlantica*).The latter two sites constitute 75% of the site of Biological and Ecological Interest of Bou Iblane 2 (including the Tanemilt site), while the Taffert site constitutes 100% of the site of Biological and Ecological Interest of Taffert (**Error! Reference source not found.**), as it lies outside Bou Iblane 2.

Outside Bou Iblane 1 and 2 lie the Mdaoud and Karya sites which are crossed by one river each (Oued Taffert at Karya and Oued ouled Mdaoud). The floodplains of these rivers are characterized by a great abundance of doum (dwarf palm) (*Chamerops humilus*). In these sites, monkey shelter in caves of the precipitous valley walls due to the absence of Atlas cedar. The GPS locations were recorded for all groups sighted.

Although the importance of the different threats to the monkeys is variable depending on the region considered, human pressure, habitat degradation and loss are identified as the main causes of the decline of this species (Conservation Action Plan for the Barbary Macaque in Morocco, 2012). The effect of the three anthropogenic factors (poaching, grazing, and tourism) and habitat degradation has an effect on the population density of the Barbary macaques in Eastern Middle Atlas.The grazing was measured by an ordinary scale, noting; 0: forest-rich woodland and no sign of goat grazing, bush plants, and turf present; 1: poor undergrowth in the forest, most shrubs modificated by grazing with most herbs removed 2: no presence of grass with the presence of livestock debris. This means the presence of a high grazed route. The degradation of the forest was measured by an ordinary scale, noting; 0: no trace of cutting trees and trees are not sick; 1: there are traces of cutting the trees and the trees are not very sick.The type of forest was measured on an ordinary scale: 2, all cedars or all oak; 1, cedar mixed with oak or oak mixed with another tree; 0.5, rare cedars or rare oak; (Mehlman 1989). For tourism, data were collected by the "scan sampling" method (Altmann J.1974), which collects on the presence of the tourist. Noting by; 1: presence of tourists close to the monkey group (distance ≤ 100 m); 0: absence of tourists. For poaching, the data were collected on an additive scale in the form of a questionnaire targeting indigenous peoples and forest administrations. These questionnaires were measured on an additive scale; 0: no poaching; 1: last poaching of juveniles in more than one year; 2: One or more poaching has been detected in less than one year. Between January 2014 and June 2015, the 325 days (3250 hours including 10 hours per census day) we identified and

counted each group based on the morphological characteristics described by Ménard in 1985 and 1993 (Ménard N. et al 1985a, 1993a).

When the groups crossed an open area like a paved road or clearing, we recorded the number and the group's composition. We distinguished six age-sex categories.

To avoid errors due to the often rapid movement of individual macaques through open spaces, I had to count ten times for each group.Lincoln-Peterson index has been used for to calculate density.$D = N/S$;

With D is the density of population, N is a total number in the area, S is the land area.

We calculated the sex-ratio (male/females) for all mature and young individuals. We calculated also sex ratio of adults and young/adult females. Data collection was based on noninvasive behavioral observation.

Statistical Analysis

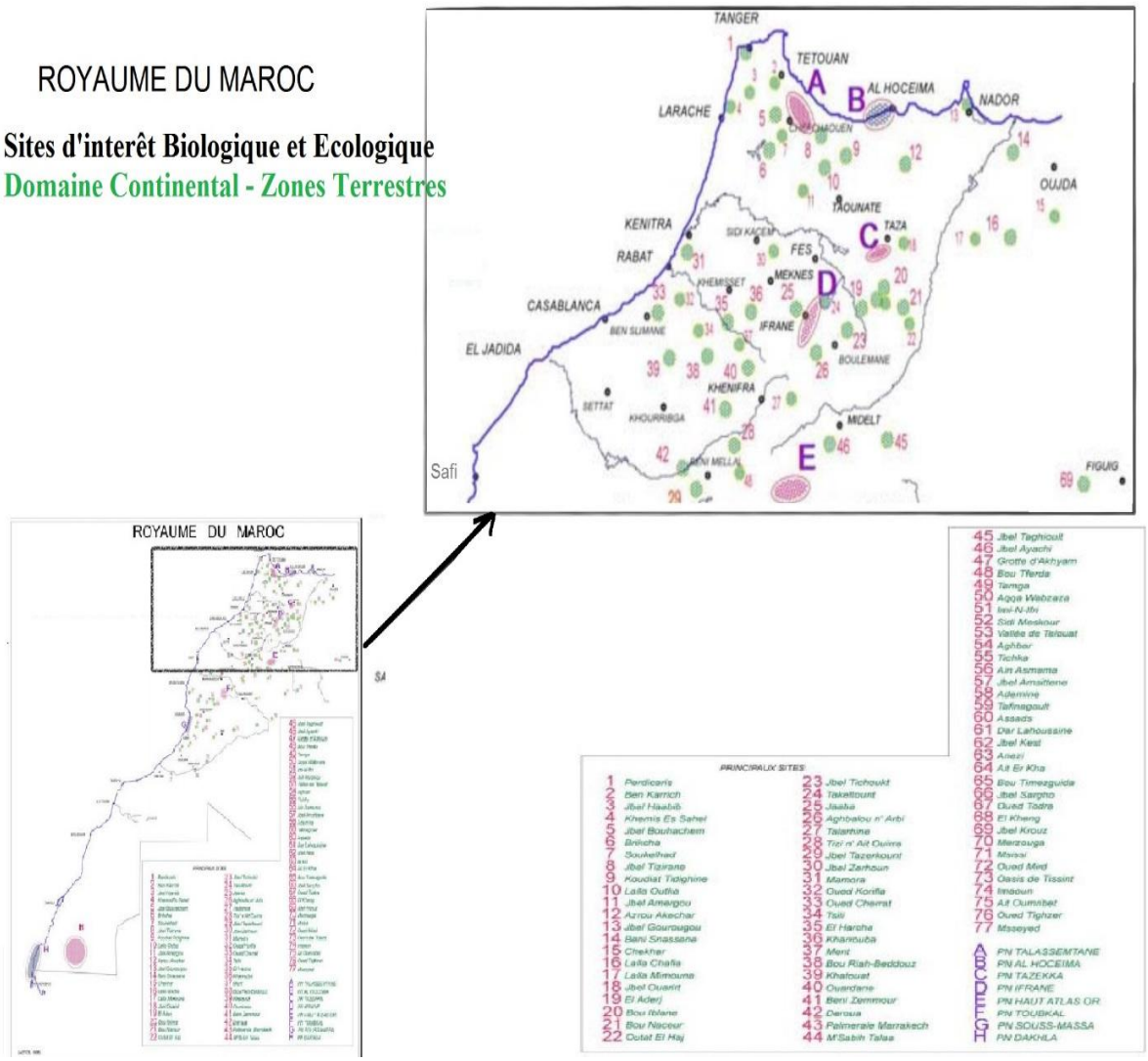
The data was analyzed in IBM SPSS 21. Regression analysis was used to compare macaque densities across Karya, Tamgilt, Taffert, and Tanemilt in the Eastern Middle Atlas region.

$$\mathrm{yi} = \beta + \beta \mathrm{i} x1,\mathrm{i} + \cdots + \beta \mathrm{k} x k, i + \epsilon i$$

With you, x1,I are fixed, ϵi represents the error.

A non-parametric Mann-Whitney U test was used to compare the home range size and the density of distribution. MANOVA was used to assess the effect of the three anthropogenic factors-poaching, grazing and tourism-and habitat degradation on the population density of the Barbary macaques in Eastern Middle Atlas.

Figure 1.Localisation of the Eastern Middle Atlas in northern Morocco



RESULTS

The composition and most complete numbers of each group taken during the survey period are detailed in Appendix A. The size of the macaque groups in this study varied from 16 to 73 individuals (20 groups = 831 individuals) with an average size of 41.55 individuals (**Error! Reference source not found.**3). Due to the rapid

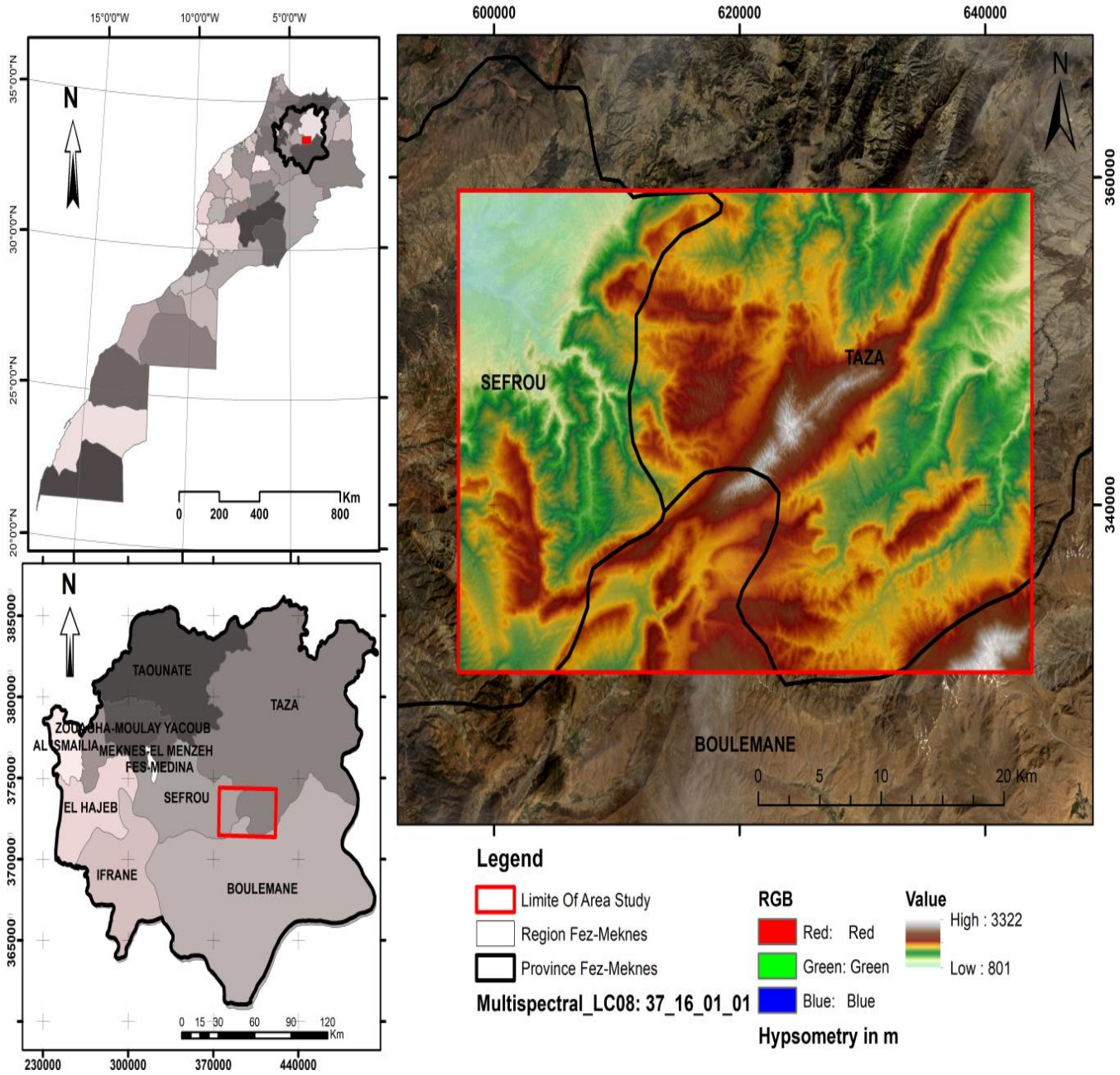
movement of group members, we were unable to identify the sex of some adults. Of those recorded, the average overall adult sex ratio was almost 1: 1.1.06.

Error! Reference source not found.4 and **Table 2** demonstrate the relatively high number of replications across our statistical units. Regression analysis between the density of each study site and the home range size shows a very significant ($\beta = 0.645$, $R^2 = 0.532$, $p < 0.001$) variation in density of Barbary macaques in the Eastern Middle Atlas.

The Fischer F test also showed a significant relationship ($F = 65061$, $p < 0.0005$) between density and home range. This is also supported with a model fit of correlation coefficient $R = 0.95$ (**Error! Reference source not found.**), indicating that home range size explains almost 94% of the population density variation. Furthermore, Mann-Whitney test results showed that there is a correlation between densities of distribution to the home range size of each group (**Error! Reference source not found.**).

The effect of the anthropogenic actions (poaching, grazing, and tourism) and habitat degradation on the population density of the Barbary macaque in Eastern Middle Atlas are identified as the main causes of the decline of this species. The analysis of the effect of the anthropogenic actions showed that the Wilks Lambda

Figure 2.Sites of Biological and Ecological Interests of Morocco (HCEFLCD, 2015 modified)



value (0.023) is associated with a very low p-value. This value is lower than the alpha risk threshold (0.05). These results may indicate that anthropogenic actions and degradation of habitat actually have no effect on the density of Barbary macaques in the Eastern Middle Atlas. Similarly, this result is likely to be correct given that MANOVA F = 24.03 and P <0.001 (**Error! Reference source not found.**).

DISCUSSION

The abundance of food resources is generally the primary factor determining monkey population density (Iwamoto 1978; Southwick et al. 1983; Altmann et al.1985). The Macaque's adaptive capacity explains the number and variety of habitats they live in (Deag 1974; Drucker 1984). Group size appears to correlate with group size recorded across similar habitats in different locations. In the deciduous oak forest in Algeria a group of 53 individuals was recorded (Menard & Vallet 1993).

Table 2.Regression analysis between the density of each study site and the home range size of the population of Barbary macaques in Eastern Middle Atlas, Morocco.

Source	Df	Somme des carrés	Moyenne des carrés	F	Pr > F
Modèle	1	25.619	25.619	65.061	0.0004
Erreur	3	1.181	0.394		
Total corrigé α =0.05	4	26.800			

Table-3.U Mann-Whitney test for the comparison between the distributions of the density and the home range size of each group of the Barbary macaque in Eastern Middle Atlas between Janary2014 and July 2015

The first study of the density of the Barbary macaque in the Middle Atlas was carried out in 1968 by Deag (1974) in Ain Kahla. He found a density of 70 individuals per km^2 (ind/km^2) with a focal method similar to ours. In 1977, Taub (1977) evaluated the density at around 44 ind/km^2 by a transect method carried out at Ain Kahla and in the Ifrane forest of Ras El Ma and Michlifen. Thirty years later, there was a significant decrease in the average Barbary macaque density from 25-30 ind/km² in 1994, to 7-10 in/km² in 2002 (Camperio Ciani et al. 2001) (**Error! Reference source not found.**5).

These figures are relatively comparable to those obtained in our study, although the method and the total number are different. Macaques' densities in the various habitats are declining even faster than habitat degradation itself (Camperio Ciani et al. 2005). The density of the population in the Middle Atlas clearly shows a progressive and drastic decline particularly in cedar habitat and degraded underbrush (Camperio Ciani et al. 2005).

Our results indicate a Barbary macaque population density ranging from three to nine ind. /km², the lowest being observed at Mdaoud and the highest in the Karya place (**Error! Reference source not found.**6).

Table 4.the multiple correlation coefficients of home range size and the population density of Barbary macaques in Eastern Middle Atlas, Morocco

The regression equation is						
density (ind/km2) = -6,95553021664761E-02+0,270239452679589*surface(km2)						
Source	Valeur	Erreur standard	t	Pr > |t|	Borne inférieure (95%)	Borne supérieure (95%)
Constante	-0.070	0.826	-0.084	0.938	-2.699	2.560
surface (km2)	0.270	0.034	8.066	0.004	0.164	0.377
Source	R	MCE	R²	R² ajusté		
1	0.977	0.394	0.956	0.941		

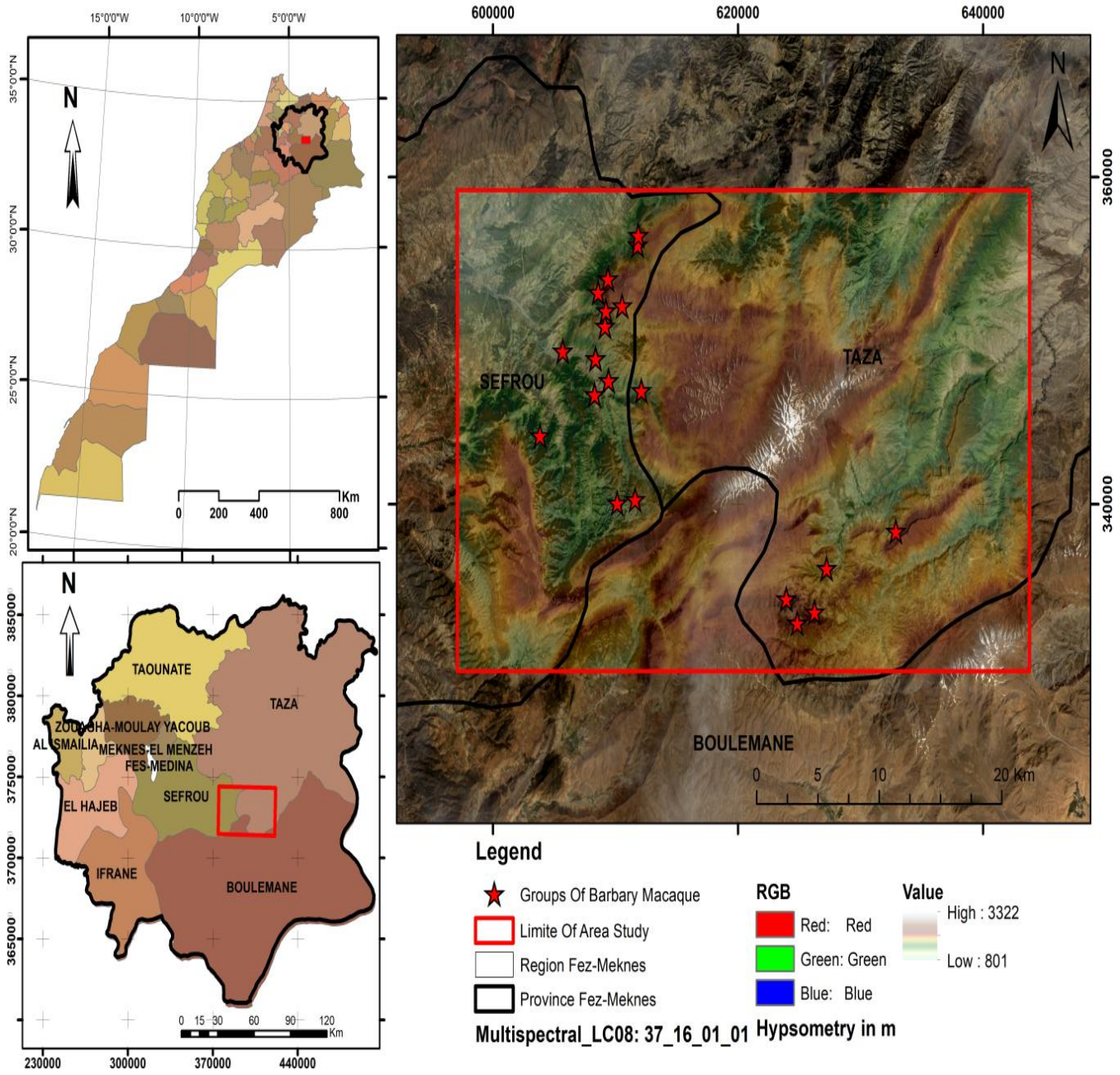
Table 5.MANOVA analysis of the effect of the anthropogenic action (poaching, grazing, and tourism) and also habitat degradation on the population density of the Barbary macaques in Eastern Middle Atlas, Morocco.

Source	Sums of Squares setting on "Type III"	df	Moyenne des carrés	F	p-value
Modéle corrigé	25255082599.113	3	8418360866.371	15.538	0.000
Ordonnée à l'origine	18302465160.890	1	18302465160.890	24.03	0.000
Antrop.Action	11124798469.638	2	5562399234.819	10.266	0.000
Degra.habitat	14232919587.062	1	14232919518.062	26.269	0.000
Error	485495478164.776	1789			
Total	1365800062500.000	900			
Total corrigé	510714560763.899	899			

For a group of wild macaques, the sexes were balanced with a roughly 1:1 female to male ratio per group, and the percentage of young macaques varies greatly depending on habitat. Previously, Menard recorded young macaques in the order of 50% of the group total (Ménard and Vallet 1993a; 1996; Ménard N. 2002); however, we have illustrated that there are between 55% and 161% across other species that live alongside macaques in similar habitat and regions of distribution (Ménard and Vallet 1996; Water et al. 2015).

Indeed, retrospective studies by Deag (1974) and Fa et al (1984) in Ain Kahla, (Ménard and Vallet 1996) in Algeria in the Djurdjura National Park and Akfadou,

Figure 3. Localisation of groups of barbary macaques in area study, Eastern Middle Atlas, Morocco



(Appendix A).

Comparing the groups makes it possible to highlight the important imbalances in group proportions of young versus adults. In this study, we found the adult sex ratio to vary between 1:0.8 and 1:1.3 compared to Drucker's (1984) data which decreased from 1:1.05 in 1980 to 1:0.36 (Drucker et al. 2002) by 1994 and 1995. The male to female ratio of approximately 1:1.06 is replicated mentioned relatively constant youth/adult ratios. The reduction of the proportion of young macaques in groups of Barbary macaques has been interpreted as a significant indicator of population decline. In these studies, the ratio of young to adult is between 53 and 174% (table 3), with a 50% average across all habitats (**Error! Reference source not found.**7).

This equilibrium seems very variable between the groups studied and oscillates between 52% and 100%. Southwick et al. (1980) have estimated that when the proportion of young people falls below one and a half times the proportion of adult females, the population begins to decline. Whereas we found that not all populations declined as some groups had an average of twice as many young as adult females (**Error! Reference source not found.**7,**Error! Reference source not found.**8and**Error! Reference source not found.**9).

In a favorable wildlife habitat, the birth rate is higher than the mortality rate and the population increases

Figure 4. Graph of Linear Regression of density (ind/km2) per surface (km2) of the population of Barbary in the Eastern Middle Atlas, Morocco

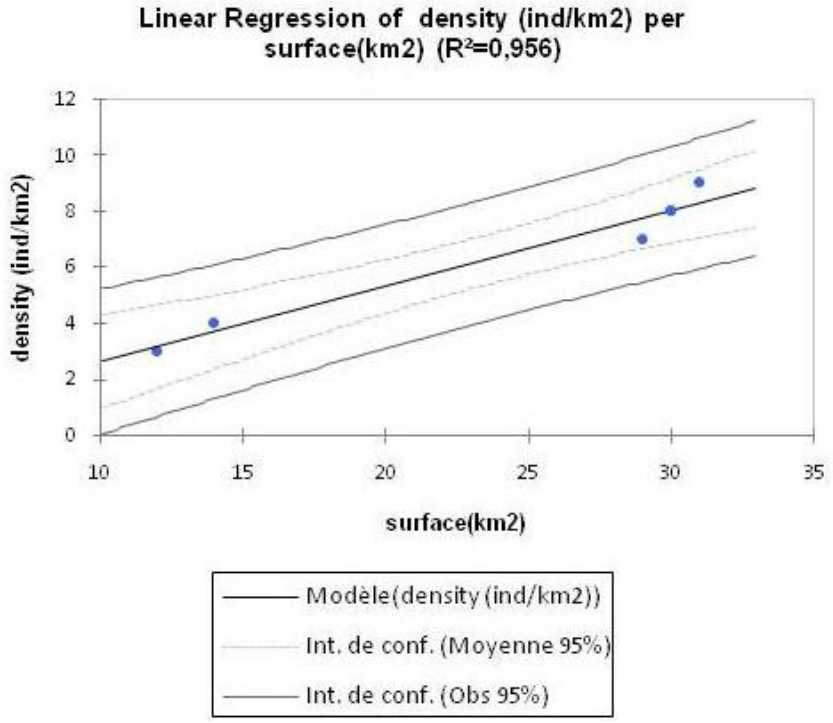


Figure 5. Graph of evolution of the density of the population of Barbary in Middle Atlas, Morocco

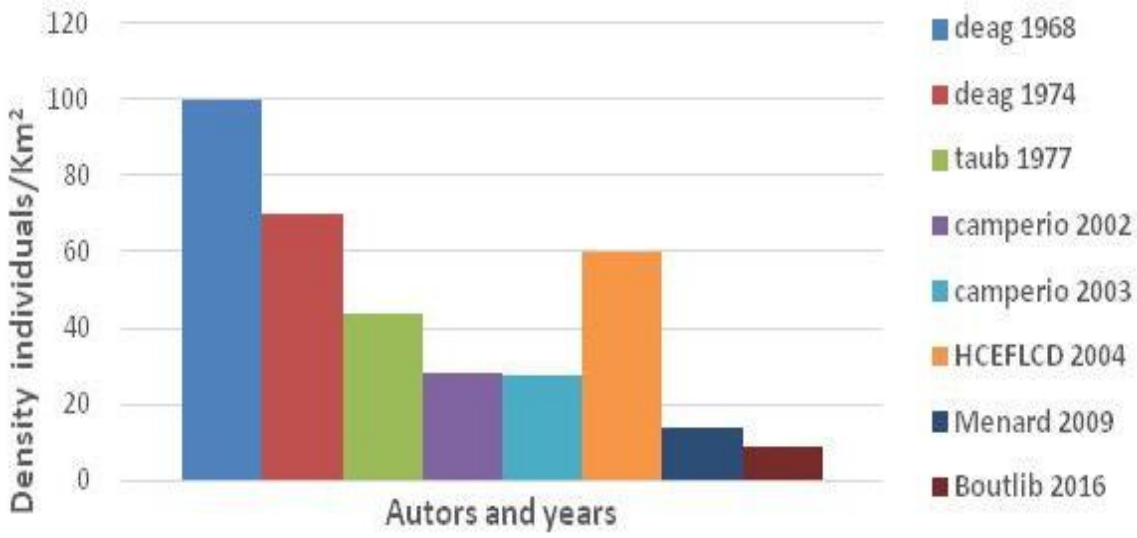


Table 6.Roy test and wilks test significative test for MANOVA analysis of population of Barbary macaques in Eastern Middle Atlas, Morocco.

	Density
Wilks' Lambda	0.023
F value	199.145
DDL1	8
DDL2	288
F value	1.971
Roy's Greatest Root	0.0345
p-value	<0.0001

Figure 6. Graph of density of wild population of Barbary macaques in Eastern Middle Atlas, Morocco.

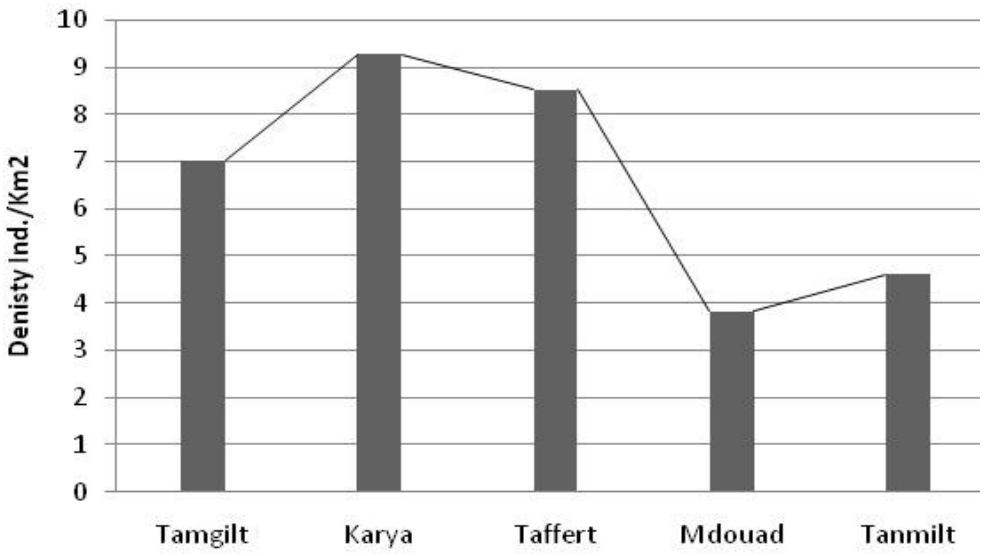


Figure 7 .Graph of Sex ratio (Males/ Females) of Barbary macaques in Eastern Middle Atlas, Morocco

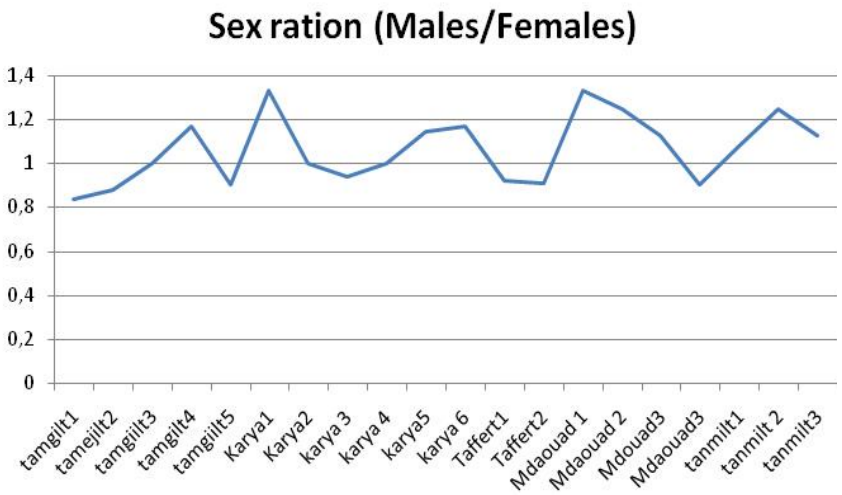


Figure 8. Graph of the proportion of relative young of adult's of population of Barbary macaques in Eastern Middle Atlas, Morocco.

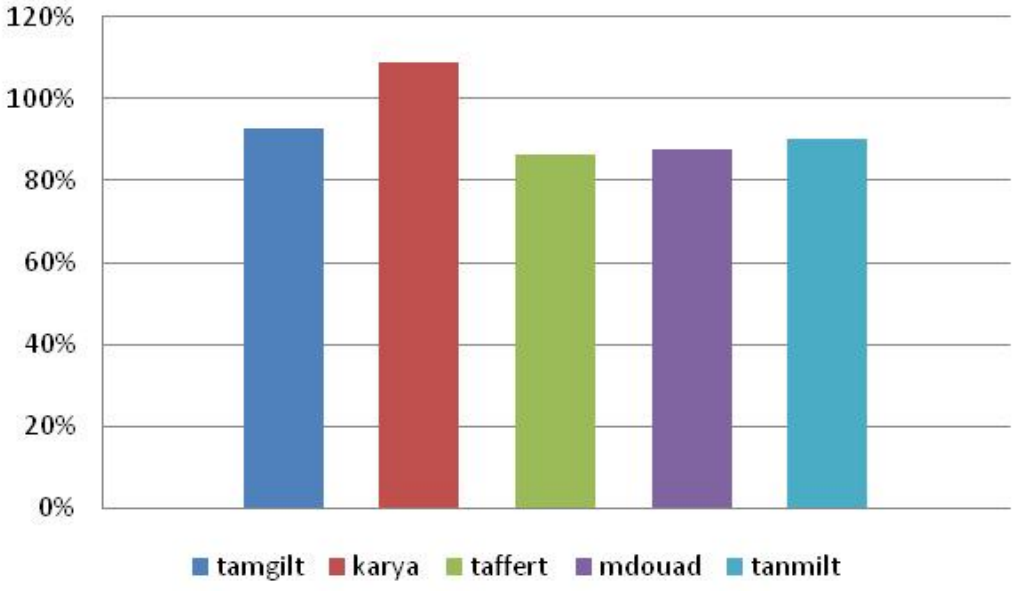
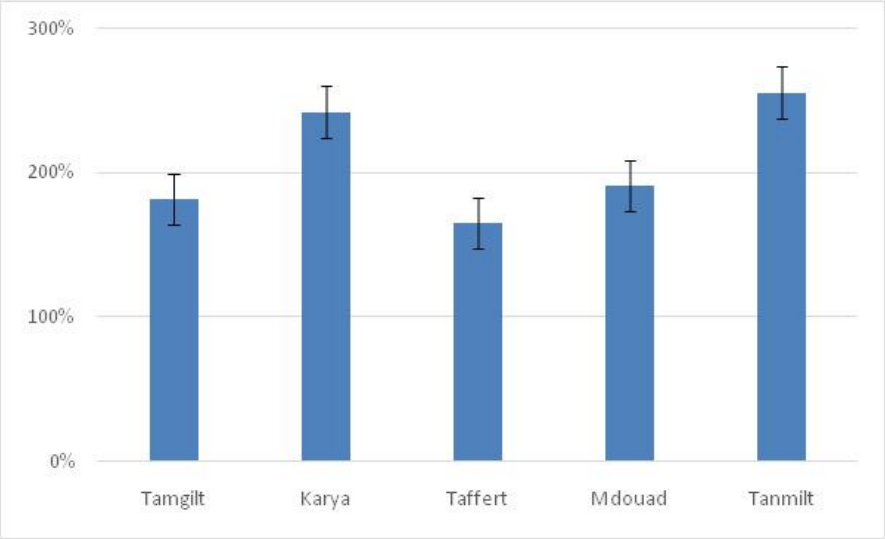


Figure 9 . Graph of the proportion of young /the proportion of the adult females of population of Barbary macaques in Eastern Middle Atlas, Morocco.



(Ménard and Vallet 1993a). The rapid increase in group size can induce its division into subgroups. Fission and migration are two common phenomena in Barbary macaque populations (Ménard N. et al. 1985b; 1990; Ménard and Vallet 1993a; 1993b). Females generally remain in their native groups and inter-group migration tends to be a male behavior (Paul and Kuster, 1987). Migration of Barbary macaques occurs over short distances (Ménard and Vallet, 1996). In this study, we found a group that had expanded to73 individuals. This group, which is located in the Karya escarpments south of Taffert, has not undergone fission or division into subgroups, despite anthropogenic actions in the region. This directly contradicts the explanations suggested by Ménard et al. (1985a; 1990), Ménard and Vallet (1993a; 1993b).

The proportion of immature animals in the population that survive the dry season (summer) correlates to habitat conditions, such as food availability and predator pressures. We suggest, therefore, that better population demographic indicators are the ratio of immature to mature individuals and the ratio between males to females. We also propose that these ratios are a better way to determine if group fission and migration have occurred. Thus, we can more effectively monitor the decline of this species and its natural habitat (Camperio Ciani et al. 1999; Camperio Ciani and Castillo 2000).

Camperio Ciani (2005) proposed that population density declines due to habitat degradation, overgrazing, tourism and poaching of young monkeys. We postulate that according to our results these factors do not appear to affect population density. The majority of the Eastern Middle Atlas environment is exposed, rocky, water eroded and sometimes inaccessible to humans, with an altitude between 1200m to 3400m. During our study, the topography dictated that we follow the rocky escarpments and ridges similar to the conditions of the Rif's mountain study conducted by Waters et al. (2015). These areas are impossible to graze, steep and dangerous areas that are naturally resistant to human interference. Our results show that habitat degradation, overgrazing, tourism and poaching does not cause a decline in population density of Barbary macaques in the region studied (

Table 6).

The Barbary macaque has been classified as a territorial species (Cooper 2001) however, the frequency of territoriality in wild Barbary macaques varies greatly depending on habitat (Deag 1985). Barbary macaques can have more extensive home ranges averaging between 11.7 ha and 25 ha in the Moroccan Middle Atlas (Fooden 2007; Fa et al. 1986, Drucker 1984) and (Machairas et al. 2003) precisely because of their terrestrial adaptability, topography, and variability of tree cover.

In Djurdjura, the home range was estimated to be 2.8 km² (Ménard & Vallet 1996). The present data show that the home range colonized by Barbary macaques can reach up to 31.2Km^2. The population density regression analysis supports this showing that population density is relative to home range size. Home range size differs significantly between groups. It is consistently smaller in nocturnal species compared to diurnal species, and terrestrial species tend to have larger home ranges than arboreal ones. Terrestrial species movements are restricted to two dimensions and their habitats are typically food sparse similarly frugivores tend to have larger home ranges than folivorous.

Comparisons between ecological categories are complicated by the close relationship between home range size and group size (Milton & May 1976). Large home ranges occur where food supplies are widely and sparsely dispersed (Milton & May 1976). Large group size will increase the distance that each individual will have to move per day to collect food (Smith D.G. 1981, Smith, E.O. and Peffer-Smith, P.G., 1982); and group

size may be affected by the distribution of food supplies (Crook 1972).

The decrease in the density of the Barbary macaque groups may be affected by habitat and resource degradation (Camperio Ciani 2005, Ménard & Vallet 1996). However, in the present study, the adjusted R2 value is proven robust and tested with a different sample from the same population, such that home range size explains almost 94% of the density variation. The regression analysis of the home range size and density reveals that the variation of density of Barbary macaques in Eastern Middle Atlas is very significant. Several hypotheses can be put forward to explain this large population: Their habitat is mainly rocky and inaccessible for shepherds and their sheep; These populations are far from civilization and well protected from anthropization (poaching, overgrazing ...); Climactic conditions are severe. In Bou Iblane the snow remains eight months during the year (wet continental bioclimate), making it an inhospitable human terrain; An abundance of nutritious varied resources.

The objective of this study is to provide information on the current status of the Barbary macaque, a potential emblematic species of the Eastern Middle Atlas.

This study demonstrates the existence of the Barbary macaque in the Eastern Middle atlas with a large population of 831 individuals across 20 groups. This is an even larger population than that recorded in the Rif, where Taub estimated the population of Barbary macaques to be between 100 and 200 individuals (Taub 1975; 1977).

This data provides a reference for a broader survey of the state of conservation of Barbary macaques in the Eastern Middle Atlas. The evidence provided shows that the regions studied; Karya, Mdaoud, Tamgilt, Tanemilt, SIBE Bou Iblane 1 and 2, SIBE Taffert and El Adrej may be key regions for long-term conservation of the species, and that National Park establishment and conservation in situ would be of great benefit to this endangered endemic species.

Compliance with ethical standards

This study was a purely observational study. All applicable international, national and institutional guidelines for the care and use of animals were followed. All procedures performed in studies involving animals were in accordance with the ethical standards of the institutions at which the studies were conducted.

Conflicts of Interest

Authors declare that there is no conflict of interests regarding the publication of this paper.

References

[1]. Abegg and Thierry (2002). Macaque evolution and dispersal in insular south-east Asia. Bio J Lin society 75(4): 555–576.

[2]. Altmann J.(1974).Observational study of behaviour: sampling methods. Behav 49 (3/4):227-267.

[3]. Altmann J., Hausfater G., Altmann S.A. (1985). Demography of Amboseli baboons, 1963-1983. Am J Primat (8):113-25.

[4]. Arambourg, C.(1959).Vertébrés continentaux du miocène supérieur de l'Afrique du Nord. Publs Surv.géol.Algér.Pal.4:1.

[5]. Benabid A.(1981).Bref aperçu sur la zonation altitudinale de la végétation climacique du Maroc. Eco méditerranea 8(1-2):301-317.

[6]. Boutlib F.., Guemmouh R., Deman C.M.F. 2016. Biodiversity of Moroccan forest: degradation facteur -cedar -Barbary macaque. Calmèo (9):1-52.

[7]. Camperio Ciani, A.(1986). La Macaca sylvanus in Marocco: soprav- vivenza o estinzione. Osservazioni personali e dati storico-demog- rafici. Antrop contemporanea 9 (2) :117–132.

[8]. Camperio Ciani, A., Mouna, M., Arahou, M., (1998).Macaca sylvanus as a biological indicator of the cedar forest quality. In: Selected Proceedings of the First International Conference on Biodiversity and Natural Resources Preservation. Al Akawayn University Press. pp. 91–98.

[9]. Camperio Ciani, A., Castillo, P., (2000). The desertification process in the last natural forest of the southern Mediterranean region. In: Balabanis, P., Peter, D., Ghazi, A., Tsogas, M. (Eds.), Proceedings of the International Conference 1996. Volume 2. Summary of Project Results. Office for Official Publications of the European Communities, Luxembourg, pp. 471–480.

[10]. Camperio Ciani, A., Martinoli, L., Capiluppi, C., Arahou, M., Mouna, M., (2001). Effects of water availability and habitat quality on bark stripping behaviour in Barbary macaques. Con Bio 15 (1), 259–265.

[11]. Camperio Ciani, A., Palentini, L.&Mouna, M.(2003). The human dimension of the recent decline and possible recovery of the central Middle Atlas forest in Morocco. In Proceedings of the Workshop of Forest Landscape Restoration, Ifrane, Morocco, 27 May–1 June 2003.

[12]. Camperio Ciani, A., Palentini, L., Arahou, M., Martinoli, L., Capiluppi, C.&Mouna, M (2005).Population decline of Macaca sylvanus in the Middle Atlas of Morocco. Bio Cons,121, 635–641.

[13]. Caughley, G. 1977. Analysis of vertebrate populations. Wiley, New York.

[14]. Conservation Action Plan for the Barbary Macaque in Morocco, 2012.

[15]. Crook, J. H. (1972). Sexual selection, dimorphism and social organization in the primates. In Sexual selection and

[16]. the descent of man, 1871-1971: 231-281. Campbell, B. (ed.). Chicago: Aldine Atherton.

[17]. Cooper, G. (2001). The behaviour and ecology of the muton macaque. BSc dissertation, University of Aberdeen, Aberdeen, UK.

[18]. Cuzin, F. (2003). Les grands mammif è res du Maroc méridional (Haut Atlas, Anti Atlas et Sahara): distribution, écologie et conservation. MSc thesis, University of Montpellier II, Montpellier, France.
[19]. Deag J.M. (1974). A study of the social behaviour and ecology of the wild Barbary macaque Macaca sylvanus. Thèse de doctorat : University de Bristol, Angleterre.
[20]. Deag J.M.(1980).Interactions between males and unweaned Barbary macaques: testing the agonistic buffering hypothesis, Behav 75(½): 54-81.
[21]. Delson, E .(1980). Fossil macaques, phyletic relationships and a scenario of deployment. In: The Macaques (Ed . by D . G . Lindburg), New York: Van Nostrand Reinhold. pp . 10-30 .
[22]. Donald G. Lindburg, Van Nostrand Reinhold.1982. The Macaques: studies in ecology, behavior, and evolution, Am J Phys Anthr 57(1):132–133.
[23]. Drucker GR.(1984). The feeding ecology of the Barbary macaque and cedar forest conservation in the Moroccan Middle Atlas. In: Fa JE, editor. The Barbary macaque: a case study in conservation. New York, NY: Plenum Press. P 135–164.
[24]. Fa, J.E., D.M. Taub, N. Menard & P.J. Stewart. (1984). The distribution and current status of the Barbary macaque in North Africa. In The Barbary Macaque: A Case Study in Conservation. J.E. Fa, ed. Plenum Press. London. pp. 79-111.
[25]. Fooden, J.(1976).Provisional classification and the key to living species of macaques (primates: Macaca). Fol Primat 25: 225-236.
[26]. Fooden J. (2007).Systematic review of the Barbary Macaque, Macaca Sylvanus (Linnaeus, 1758). Fieldiana Zool. 113:1–60.
[27]. Fennane M.(1982). Analyse phytogéographique et phytoécologique des tétraclinaies marocaines. Thèse de 3ème cycle., Univ. Aix Marseille III 146p.
[28]. Hayasaka,K.,K.Fujii, AND S. Horai. (1996). Molecular phylogeny of macaques: Implications of nucleotide sequences from an 896-base pair region of mitochondrial DNA. Mol Bio Evo, 13: 1044–1053.
[29]. IUCN .(2006).The IUCN Red List of Threatened Species.International Union for Conservation of nature.Switzerland. Available from http://www.iucnredlist.org/details/12561/0(accessed March 2015).
[30]. IUCN .(2011).IUCN red list of threatened species. International Union for Conservation of Nature. Switzerland. Available from www.iucnredlist.org(accessed March 2015).
[31]. Iwamoto T. (1978). Food availability as a limitation factor on population density of the Japanese monkey and Gelada babbon. In Recent advances in primatology (Chivers DJ, Hebert J, editors). London: Academic press. pp 287-303
[32]. Kurten, B.1968.Pleistocene mammals of Europe.London: Weidenfels & Nicolson, 24,pp.47-9.
[33]. Linnaeus, (1758). Systema Naturae ..., 10th ed, vol. 1. Impensis Direct. Laurentii Salvii, Holmiae, 823 + 1 + 3 pp.
[34]. Maréchal L, Semple S, Majolo B, Qarro M, Heistermann M, MacLarnon A (2011). Impacts of tourism on anxiety and physiological stress levels in wild male Barbary macaques. Biological Conservation 144, 2188-2193. http://www doi.10.1016/j.biocon.2011.05.010 Published: SEP 2011
[35]. Mehlman, P.T.(1989).Comparative density, demography and ranging behaviour of Barbary macaques (Macaca sylvanus) in marginal and prime conifer habitats. Int J of Primat10 :pp. 269-292.
[36]. Ménard, N., VALLET, D. et GAUTIER-HION, A.(1985)a. Démographie et reproduction de Macaca sylvanus dans différents habitats en Algérie. Fol Primat 44 :65-8 1.
[37]. Ménard, N.(1985)b. Le régime alimentaire de Macaca sylvanus dans différents habitats d'Algérie : 1. - Régime en chênaie décidue. Rev. Eco/. (Terre Vie) 40(45):1 -466.
[38]. Ménard N, Vallet D.(1986).Le régime alimentaire de Macaca sylvanus dans différents habitats d'Algérie : II-régime en forêt sempervirente et sur les sommets rocheux (in French with English summary). Revue d'Eco Terre ET La Vie. 41 :173–192.
[39]. Ménard N, Hecham R, Vallet D, Chikhi H, Gautier-Hion A (1990). Grouping patterns of a mountain population of Macaca sylvanus in Algeria - a fission-fusion system? Fol Primat 55, 166-175.
[40]. Ménard, N. & D. Vallet.(1993)a.Population dynamics of Macaca sylvanus in Algeria - an 8-year study. Am J Prim 30:101-118.
[41]. Ménard, N & Vallet D. (1993)b. Dynamics of fission in a wild Barbary macaque group (Macaca sylvanus). Int J Prim 14:479–500.
[42]. Ménard, N. & D. Vallet. (1996). Demography and ecology of Barbary macaques (Macaca sylvanus) in two different habitats. In Evolution and Ecology of Macaque Societies. J.E. Fa and D.G. Lindburgh, eds. Cambridge University Press., Cambridge. pp. 106-131.
[43]. Ménard, N., Vallet, D., (1997) Behavioral responses of Barbary macaques (Macaca sylvanus) to variations in environmental conditions in Algeria. Am. J. Primatol. 43, 285–304
[44]. Ménard N. (2002). Ecological plasticity of Barbary macaques (Macaca sylvanus). Evo Anthro 1, 95-100.
[45]. Swapna Gurrapu and Estari Mamidala. In vitro HIV-Reverse Transcriptase Inhibition of Andrographolide Isolatedfrom Andrographis Paniculata. European Journal of Biomedical and Pharmaceutical Sciences. 2017. Volume 4, Issue 12. 516-522.
[46]. Ménard N., Rantier Y., Foulquier A., Quarro M.(2009).Impact of human pressure and forest fragmentation on the Endangered Barbary macaque (Macaca sylvanus) in the Middle Atlas of Morocco, Evo eco maca societies 48(02):276-284.
[47]. Milton K., May M.L.(1976). Body weight, diet and home range area in primates, Nature, Lond. 259: 459-462.
[48]. Mouna, M., Arahou, M., Camperio Ciani, A., (1999). A propos des population du singe magot (Macaca sylvanus) dans le Moyen Atlas.In: Proceedings of the First International Conference on Biodiversity

and Natural Resources Preservation. Ifrane, pp. 105–109.
[49]. Mouna M., CAMPERIO CIANI A. (2006). Distribution, and demography of the Barbary macaque in the wild. In JK Hodges, J. Cortes (Eds), The Barbary macaque, biology, management, and conservation. Nottingham,Nottingham University Press, Nottingham, 199–210
[50]. National Research Council. (1981). Techniques for the study of primate population ecology. National Academy Press, Washington, D.C.Lara Modolo, Walter Salzburger et Robert D. Martin.2005. Phylogeography of Barbary macaques (Macaca sylvanus) and the origin of the Gibraltar colony. Proceeding of the National Academy of Sciences o the United States of America 102(20):7392–7397.
[51]. Oates, J.F.(1996). Habitat alteration, hunting and the conservation of folivorous primates in African forests. Australian Journal of Ecology 21: 000-000. Om the London clay. Geogr. Mag 2: 339-341.
[52]. Owen, R.(1865).On the marsupial pouches, mammary glands, and mammary foetus of the Echidna hystrix. London.Phil Trans R Soc 155: 671-686.
[53]. Paul A, Kuster J. (1987). Dominance, Kinship and reproductive value in female Barbary macaque (Macaca sylvanus) at Affenberg Salem. Behav Eco Sociobio 21, 323-331.
[54]. Pinto, L. P. S., C. M. R. Costa, K. B. Strier, and G. A. B. Da Fonseca. (1993). Habitat, density and group size of primates in a Brazilian tropical forest. Fol Prim, 61:135–143.
[55]. Rahou A.(1996).Aperçu sur le climat et la végétation de Bou Nacer (Moyen-Atlas oriental, Maroc). Rabat.Bull, Inst. Sei.20 :113-122.
[56]. Scheffrahn, W., Ménard, N., Vallet, D. &Gac¸i, B. (1993). Ecology, demography, and population genetics of barbary macaques in Algeria,Prim 34 (3):381–394.
[57]. Waters S., El Harrad A., Chetuan M. and Amhaouch Z. (2015). Barbary Macaque Group Size and Composition in Bouhachem Forest, North Morocco, Afr Prim 10: 53-56.
[58]. Simons, E.L.(1972).Primate evolution, Macmillan, , New York.
[59]. Sindhu Radhakrishna, Michael A. Huffman, Anindya Sinha.(2013).The Macaque Connection: Cooperation and Conflict between Humans and Macaques 257 edition number 1.
[60]. Southwick, C.H., Richie, T., Taylor, H., Teas, J., Siddiqi, M.H.(1980). Rhesus monkey populations in India and Nepal: patterns of growth, decline, and natural regulation. In: Cohen, M.N., Malpass, R.S., Klein, H.G. (Eds.), Biosocial Mechanisms of Population Regulation. Yale University Press, New Haven, pp. 151–170.
[61]. Southwick C.H., Siddiqi M.F., Oppenheimer J.R. (1983). Twenty-years changes in rhesus monkey populations in agricultural areas of northern India. Eco 64, 434-439.
[62]. Smith, D.G., (1981), The association between rank and reproductive success of male rhesus monkeys. Am J Prim 1: 83-90.
[63]. Smith, E.O. and Peffer-Smith, P.G., (1982). Triadic interactions in captive Barbary macaques (Macaca sylvanus, Linnaeus, 1758): "agonistic buffering"? Am J Prim 2: 99-107.
[64]. Taub, D.M. (1975). Geographic distribution and habitat diversity of the Barbary macaque (Macaca sylvanus) in Morocco and Algeria and their conservation. Unpublished report to the New York Zoological Society, Fauna Preservation Society of Great Britain and the International Union for the Conservation of Nature, pp.71 mimeo.
[65]. Taub, D.M.(1977). Geographic distribution and habitat diversity of the Barbary macaque (Macaca Sylvanus L.). Folia Priml.27(2):108–133.
[66]. Taub, D.M. (1978). The Barbary macaque in North Africa.Oryx, 14: 245 253.
[67]. Van Lavieren, E. (2008). The illegal trade in Barbary macaques from Morocco and its impact on the wild population. Traffic Bulletin 21: 123–130.
[68]. Van Lavieren, E. (2009). Status of the Barbary macaque in the Middle Atlas of Morocco [L'état du Singe Magot dans le Moyen Atlas au Maroc, Afr Zoo 47(1):74-79.